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REASONS FOR THE LOSS OF WINTER WHEAT IN THE WESTERN URALS

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Up to the present time, winter wheat has not been cultivated on a large scale in the Western Urals primarily because of frequent losses of crops during wintering. The application of agro-technical methods have not given positive results. Previously, it was supposed that the loss of winter crops was caused by the low temperatures of the winter period. Observations taken ~~on~~ at the Krasnoufimsk Selection Station, over a period of years, show the coldest months of the year to be characterized by the following temperatures:

Air Temperature*	Nov	Dec	Jan	Feb	Mar
Mean daily	-6.3	-15.2	-16.3	-14.7	-8.7
Mean daily minimum	-26.5	-33.5	-38.1	-36.2	-30.3

The presence of temperatures as low as 38 degrees below zero, with an absolute minimum in some years of 48 degrees below zero, naturally led to the conclusion that the loss of crops was due to cold weather.

For this reason, in 1936 the Krasnoufimsk Selection Station began to develop means of combatting winter wheat losses, primarily by creating more favorable temperatures for the crops during the winter period. Experiments were conducted over a period of 3 years by drilling the seeds into the ground and by covering the seeds with straw at different periods. Results of the experiments are shown in the following table:

* All temperature readings are centigrade

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Loss of Winter Wheat(in Percentage)

Years	Snow cover		Straw cover		Spring during melting of Snow	Seeds Drilled in-to Ground
	20 cm	30 cm	Autumn	Winter		
1936 - 37	33.1	37.8	43.8	31.0	53.2	—
1937-38	63.8	66.8	99.8	98.5	98.5	97.5
1938 -39	84.0	88.0	92.0	94.0	94.0	98.5

As is evident from the chart, when the seeds ~~are~~ were drilled or covered with straw, crop losses increased instead of decreasing, in spite of the fact that the straw cover provide~~s~~d higher temperature conditions. Observations showed that the temperature was nearly 5 degrees below zero in January 1939 when ~~it was~~ there was a 30 cm snow cover, whereas with a straw cover the temperature was only 3 degrees below zero. Additional study of winter wheat losses on exposed sections showed that the more cold-resistant types of seeds were able to endure frosts of 30 degrees below zero. When these seeds were removed to the laboratory, they sprouted normally. Experiments by Academician Lysenko with Alabasskiy wheat under Siberian conditions indicated that this type could endure a temperature of 33 degrees below zero. Observations taken at the Krasnoufimsk Selection Station over a period of years prove that the temperature under a snow cover does not drop to less than 11 degrees below zero even in the coldest winters as shown by the following table:

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Years	Nov.		Dec.		Jan.		Feb.		Mar.	
	snow cover in centimeters	temperature under snow	snow cover in cm	temp. under snow	snow cover in cm	temp. under snow	snow cover in cm	temp. under snow	snow cover in cm	temp. under snow
1939-40	11.0	-5.7	16.7	-6.2	29.0	-10.9	38.3	-9.8	33.5	-6.2
1940-41	8.0	-3.0	31.6	-2.9	42.5	-5.0	43.7	-4.5	46.0	-2.5
1941-42	14.3	-3.5	19.2	-4.0	40.9	-2.8	47.3	-4.7	50.0	-3.0
1942-43	14.3	-1.0	23.6	-2.0	34.4	-4.7	49.2	-6.9	47.5	-3.1
1943-44	8.1	-3.0	23.8	-2.3	51.0	-2.5	66.4	-2.5	67.4	-0.6
1944-45	9.5	-4.4	14.0	-7.9	16.0	-10.2	17.0	-10.5	26.0	-5.6
1945-46	18.0	-2.0	41.0	-3.1	58.0	-4.5	66.0	-3.5	72.0	-1.6
1946-47	15.0	-1.5	22.0	-4.0	28.7	-4.2	32.5	-5.0	41.0	-2.3

During these winters the snow cover was quite thick, reaching 70 centimeters and more at times. The presence of this snow cover was the determining factor in the rather high temperature of the ground which fluctuated at about 4 degrees below zero most of the years. After studying the temperature pattern of winter crops, a number of scientists came to the conclusion that winter wheat wintered best under a snow cover and with a temperature of 10 degrees below zero. In the last 10 years, two winters, 1939-40 and 1944-45, stood out sharply as representing periods of relatively small snowfalls and extremely low temperatures. The snow cover during these periods was only half the normal snow cover and the air temperature dropped to 48 degrees below zero. The temperature under the snow averaged nearly 10 degrees below zero.

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The winter wheat harvest amounted to 25 centners per hectare in 1940 and 30 centners per hectare in 1945. On the other hand, a large part of even winter rye was lost during the 1942-43, 1944 and 1946 winters which were characterized by a heavy snow cover and moderate weather with temperatures under the snow cover of only 2 and 3 degrees below zero.

It is evident, then, that the loss of winter wheat crops in the Western Urals, is not caused by low air temperatures but by the relatively high temperatures under the snow cover which cause very important physiological changes in the plants.

Experiments conducted ~~Under the conditions~~ of the Krasnoufimsk Selection Station have proved that winter wheat plants may come up prematurely. If they pass through the stage of vernalization during the winter and complete this process by March, the winter wheat plants not only become more sensitive to temperature changes, but generally develop all their vital processes more intensively. The work of P. E. Potapova proved that winter wheat plants after passing through the stage of vernalization respire more energetically than plants less developed. He explained this phenomenon by the fact that the vernalized plant's capacity for anabiosis is lowered after passage of the stage of vernalization. (periodical Selektsiya i Semenovodstvo [Selection and Seedgrowing] No. 1, 1939). The higher temperatures (2 to 3 degrees below zero) under the snow which aid the vernalization process, at the same time cause a varied degree of intensity in the respiration process. The degree of intensity will depend both on the temperature under ~~and~~ the snow and on physiological changes in the plant's development.

The process of respiration is carried out with energy provided by the decomposition of organic substances, especially carbohydrates, which

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have been accumulated by the plant in the process of photosynthesis. The amount of carbohydrate reserve which is necessary for the plant's existence under a snow cover and at suitable temperatures, is shown by the following data of Professor Tumanov: Winter wheat plants with a sugar reserve of 25 percent begin to die off after being under a snow cover 50 days if the temperature under the snow is about zero. Plants with the same sugar reserve will not die off until they have been under the snow 115 days if the temperature under the snow is 7 degrees below zero. Consequently, winter wheat plants growing under Western Ural temperatures (almost 4 degrees below zero) may be expected to die of exhaustion before the snow cover melts, even if they have a sufficient reserve of sugar. Results of observations of wintering wheat, taken over a period of years, are shown in the following table:

Wintering Conditions	Average percentage of winter wheat lost per month					
	Nov	Dec	Jan	Feb	March	April
Favorable	0	0	2	8	13	30
Unfavorable	0	2	20	42	81	94

In years most unfavorable for wintering, the greatest plant loss was observed in March; and in some years the loss during this month reached 100 percent.

These losses are explained, first, by the rather high temperatures under the ground and, secondly, by the new physiological condition of the plant (a consequence of the termination of the stage of vernalization), which is characterized by an increased respiration intensity. The combination of high underground temperature and the new physiological condition of the plant hastens the output of the products of photosynthesis with the result that the winter wheat plant begins to die of exhaustion long before its spring growing period.

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When winter wheat losses under Western Ural conditions occur during periods of high temperatures (under the snow), an increased intensity of physiological processes takes place in the plant, which in turn leads to the plant's premature exhaustion and subsequently to the loss of the plant before the snow cover melts. This situation can be improved, first, by providing conditions which will guarantee maximum accumulation of the products of photosynthesis by the plants during the autumn period and, secondly, by lowering the temperature under the snow cover, thus making possible economical consumption of feed substances.

With the above conditions as a basis, the Krasnoufimsk Selection Station in 1946 undertook new experiments to find ways of combatting the loss of winter crops.

As a first step, it was decided to try methods of packing snow with the aim of lowering the temperature on the ground's surface.

Past experiences in the Urals showed that many winter crops had wintered under packed snow without being damaged. A heavy wooden corrugated roller was built to pack the snow. The roller was 75 cm in diameter and capable of packing 4-5 hectares in 8 hours.

In 1946 an experiment was conducted with winter rye on a field of 0.5 hectares. On 25 December, snow, 18-20 centimeters deep, covered the field. A single rolling packed the snow to 12 centimeters.

The temperature under the snow was recorded through the winter. These data are shown in the following table:

	Temperature of Ground Surface			
Variants	Dec	Jan	Feb	March
Under packed snow	-4.7	-9.0	-7.6	-3.1
Not packed	-3.4	-4.2	-4.0	-2.5

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It is apparent from this table, the temperature of the ground surface was considerably lower on the snow packed field than it was on the non-packed field. The ground froze 63 centimeters deep on the snow packed field and only 40 centimeters on the other. The plants in the snow packed field sprouted 3-4 days later than those on the non-packed field. Since the 1947 spring was characterized by recurring cold waves, plants which had started to sprout early suffered greatly. The very important role of snow packing during the cold winter of 1947 is indicated by the fact that the harvest on the experimental (snow packed) fields was 29 centners per hectare, whereas non-packed fields yielded only 23.8 centners per hectare. Even rye, the most winter-resistant crop, showed a marked increase in yield as a result of packing the snow cover.

Incidentally, rye suffers more from an abundance of snow than does wheat.

Late sowing is a serious fault in winter wheat cultivation in the Urals.

It is common belief that the best time for sowing in the Western Urals is between 15 and 20 August. However, it is known that 55 to 60 days are needed for the normal development of crops in the autumn period from the time of seeding to the arrival of daily mean temperatures below 5 degrees above zero, which usually takes place about 26-27 September. Consequently, instead of the 55 to 60 days which are needed for the autumn development of winter wheat, sowing between 15 and 20 August only allows 40 days for autumn development. If the low temperatures of September which retard the growth of the plant are taken into consideration, the insufficient preparation of the plant for wintering becomes obvious. The plant grows only 3 or 4 stalks and the root system develops only slightly (the secondary root system only begins to appear).

Under these conditions, the plant enters the winter period with an insufficient quantity of the products of photosynthesis. As a result,

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in years of suddenly recurring spring frosts, great numbers of plants perish because they are not firmly entrenched in the ground.

Circumstances urgently required that the sowing time for winter wheat be changed. However, experimental work data showed that early August sowing often led to large crop losses beginning from the autumn period.

These losses are explained by the fact that the plants, wheat in particular, enter the winter period while passing through the stage of vernalisation ~~and~~, consequently, many of them die.

Experiments in early summer periods for sowing were started in 1940 and indicated that when the plants were sown as early as ~~the~~ 10 June, most of the plants entered the winter period/with ~~xxxxx~~ vernalization incomplete. Further research showed that late July sowing improves the nature of the seed strain, making it more winter-resistant and productive. Likewise, plants sown at this time generally winter better.

Results of experiments with various dates for sowing winter wheat (of the variety Lyutestens 0329) begun in 1946 are shown in the following table:

Years	Time of Sowing	Wheat harvest (centners per hectare)
1947	25/VII	15.2
	20/VIII	2.7
1948	25/VII	24.8
	20/VIII	12.0

As is apparent from the chart, even in a year as unfavorable for winter wheat as 1946-47, when severe spring frosts were recorded, the harvest of wheat sown in July amounted to 15.2 centners per hectare whereas ~~while~~ the harvest of wheat planted on 20 August was only 2.7 centners per ~~to the~~ hectare.

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In 1947-48 the harvest was 24.8 and 12.0 centners per hectare respectively.

The plants sown in July enter the winter period in a strong, healthy condition. By winter, they have developed 10 to 12 stalks and have a well developed root system.

Winter wheat experiments were conducted in 1947-1948. The snow was rolled on the 25 of December. Before being rolled, the snow was 18 to 20 centimeters thick and the ground was only frozen to a depth of 7 centimeters. The temperature under the snow remained fairly constant at about 2 degrees below zero.

After the snow had been rolled, the temperature dropped sharply and the frost penetrated more deeply into the ground.

Data showing temperature changes under the snow cover, dependent upon the thickness of this cover are presented in the following table:

Elements observed	December		January		February		March		April	
	Packed Snow	Non-packed Snow	Packed Snow	Non-packed Snow	Packed Snow	Non-packed Snow	Packed Snow	Non-packed Snow	Packed Snow	Non-packed Snow
Temperature under Snow	-5.0	-2.0	-5.0	-2.7	-5.0	-3.1	-4.8	-3.0	-3.0	-0.1
Depth of Ground Frost in Centimeters	30.5	19.8	37.0	23.0	42.0	29.0	49.5	30.5	49.0	30.5
Thickness of Snow Cover	15.0	23.0	39	40	51	46	58.5	57.2	62	63

It is evident from the chart that the temperature under the snow dropped after the snow was packed and remained noticeably lower throughout the winter than on the non-packed fields. Frosts penetrated the ground

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50 centimeters on the snow packed fields, but only 30.5 centimeters on the non-packed fields.

From January on, the thickness of the snow cover remained the same on both the snow packed and non-packed fields. The following table compares losses of winter wheat plants on fields with packed and non-packed snow.

Loss of Winter Wheat Plants (in Percentage)

Time of Sowing	December		January		February		March		April	
	Packed Snow	Non-packed Snow	Packed Snow	Non-Packed Snow	Packed Snow	Non-packed Snow	Packed Snow	Non- packed Snow	Packed Snow	Non-packed Snow
25/VII	0	0	0	0	5.0	4.8	2.0	5.0	3.1	19.4
20/VIII	0	0	2.7	0	5.5	4.7	10.7	43.9	19.4	68.0

For successful wintering, crops depend upon favorable sowing dates and snow packing. July sowing sharply reduces crop loss. Although only 19.5 percent of the plants sown in July on fields without snow packing were lost, plants sown in August and wintered under the same conditions suffered losses up to 68 percent.

Snow packing sharply reduces loss among plants sown in either period. Rolling also sharply curtails losses of plants sown during both months with July losses dropping from 19.5 to 3.1 percent and August losses from 68 to 19.4 percent.

Deeper ground frosts in the sections with packed snow retarded sprouting of the plants in the spring.

Plants sown on the experimental, rolled fields, as in the experiment with rye, sprouted 3 to 4 days later than plants sown on the non-packed fields. This same phenomenon was also observed in experiments made during the winter period.

This later sprouting is a very important factor in plant survival during recurring spring frosts.

Data showing the winter wheat yield in relation to the time of sowing and the packing of the snow cover is shown in the following table.

Sowing Period	Yield in Centners per Hectare		
	With Snow Packing	Without Snow Packing	Percentage of Non-packed plots
5/VII 1947	30.3	24.8	122.0
20/VIII 1947	20.6	12.0	171.0
Increase from July Sowing	9.7	12.8	—

These data show the great effectiveness of snow packing during both these sowing periods. For the 25 July sowing, the additional yield amounted to 5.5 centners or a 22 percent increase over the yield of non-packed fields. For the 20 August sowing, the additional yield was 8.6 centners or a 71 percent increase.

The largest yield, 30.3 centners per hectare, was obtained from the 25 July sowing wintered under packed snow. The additional yield was 18.3 centners per hectare or 153 percent in excess of the harvest obtained from the 20 August sowing which wintered under normal non-packed snow cover.

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Conclusions

1. The work of the Krasnoufimsk Selection Station proved that under Western Ural conditions the presence of a fairly deep snow cover of 70 centimeters or more in some years causes an increase in the temperature of the ground's surface (4 degrees below zero) during the winter. Under such wintering conditions, the processes involved in the plant's development and respiration are intensified and, consequently, the food reserve ~~of~~ accumulated by the plants in the fall is used up more rapidly.

As a result, the plant uses up its food supply even before it sprouts under the snow (usually in March) and it then dies from exhaustion.

2. Many winter wheat plants which have emerged from the snow cover in a weakened condition are still capable of vigorous growth owing to their having passed through certain stages of development. These plants begin to grow with the first spring thaws but later die from recurring spring frosts.

3. Sowing winter wheat plants during 15 to 20 August (considered the optimum period for sowing) does not give them sufficient time for their growth and development and, consequently, for the accumulation of the necessary ~~of~~ food reserve. The plants come out in winter thinly bushed out and with poorly developed root systems. As a result, during years of severe spring frosts, they die of exhaustion.

4. On the basis of experiments conducted by the Krasnoufimsk Selection Station on winter wheat and rye, it may be assumed that packing snow over winter grains in December by a corrugated roller will enable them to winter better under Western Ural conditions.

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Sowing winter wheat at an earlier date (25 July) permits the plants to develop more fully and to accumulate a sufficient quantity of the products of photosynthesis during the autumn period.

Utilising these methods and observing all the other rules for the cultivation of winter grains (proper working of the soil, spreading of manure, etc.), workers at the Krasnoufimsk Selection Station harvested 30.3 centners of winter wheat per hectare.

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